BRAHMS

Annual RHIC DOE Science and Technology Review

July 24, 2006

F.Videbaek

BRAHMS Spokesperson

Physics Department

BNL

Overview

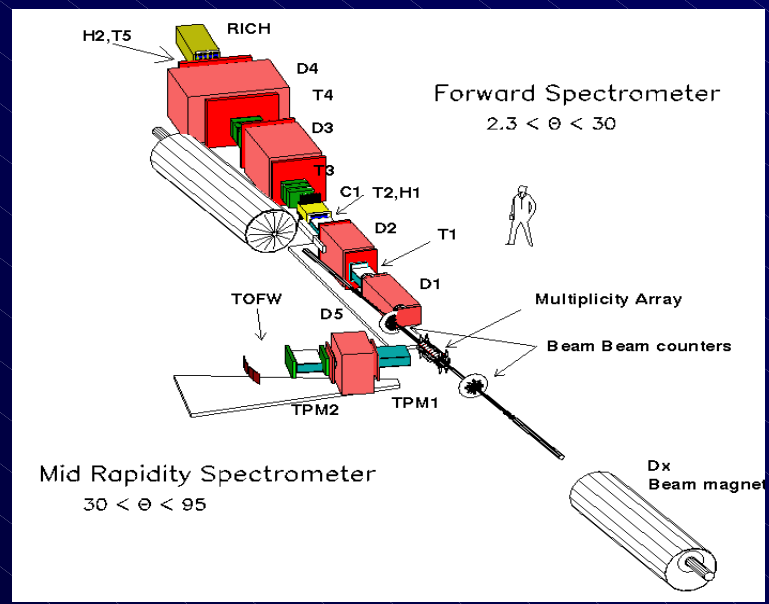
- Science and priorities
  - How has BRAHMS addressed the program set forth initially, and the science priorities of RHIC
- Accomplishments
  - Recent results.
  - Scientific output
  - Run-6 performance
- **Plans**
  - Expected results from ongoing analysis
  - Plans for future analysis.

BRAHMS Experiment and Goals

Physics questions that are being addressed

- How much energy is available for particle production ?
- How do particles flow in the transverse & longitudinal direction?
- What is the chemistry of the system?
- What is the rapidity dependence of jet quenching ?
- What can we learn about the parton distributions in the Au nuclei at small x?
- What is internal angular momentum in proton?

•The experiment has unique capabilities in terms of precision measurements and particle ID covering a rapidity range of 0-4 and up to moderate high pt (~4 GeV/c)



RHIC Science Questions

BRAHMS has addressed significant questions about strongly interacting matter:

- "How does matter behave at very high temperature and/or density?"
  - Jet-quenching suppression in AA, not d-A
  - Au-Au, Cu-Cu, pp. Bulk properties energy dependence

"What is the nature of gluonic matter? and how does it appear inside of strongly interacting particles?"

- d Au at high rapidities (low-x)

"What is the spin structure of the nucleon ?"

- Single Spin Asymmetries at large x_F

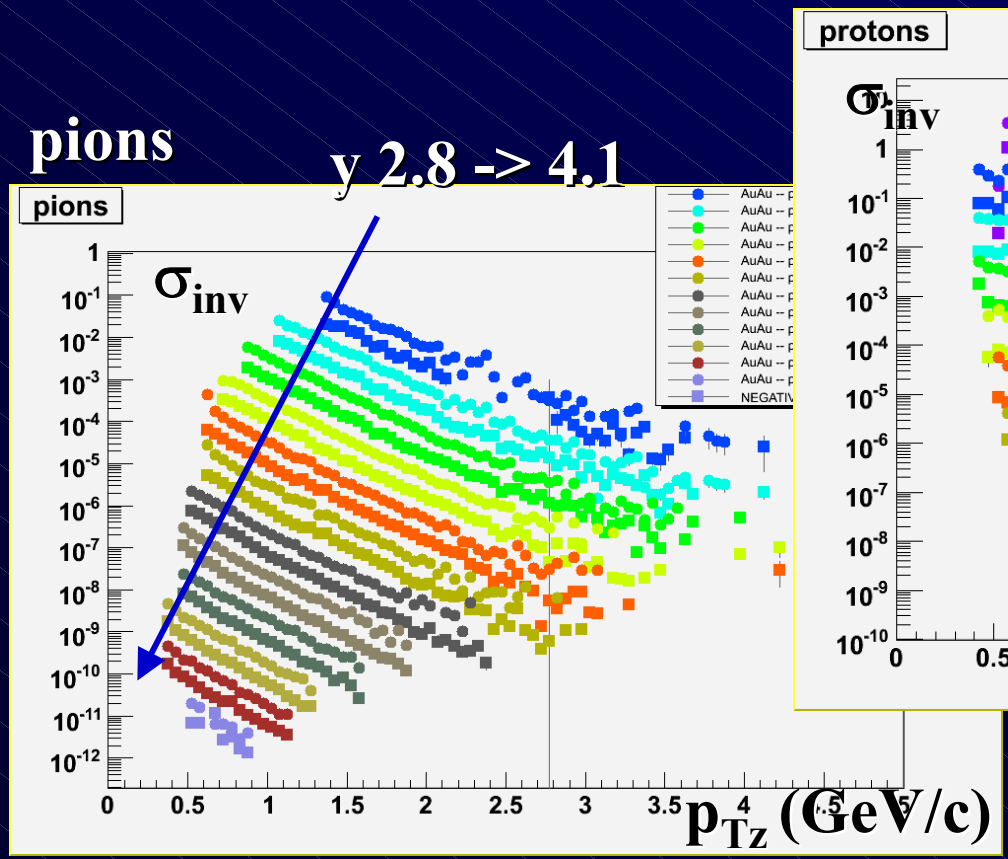
Spectra Analysis

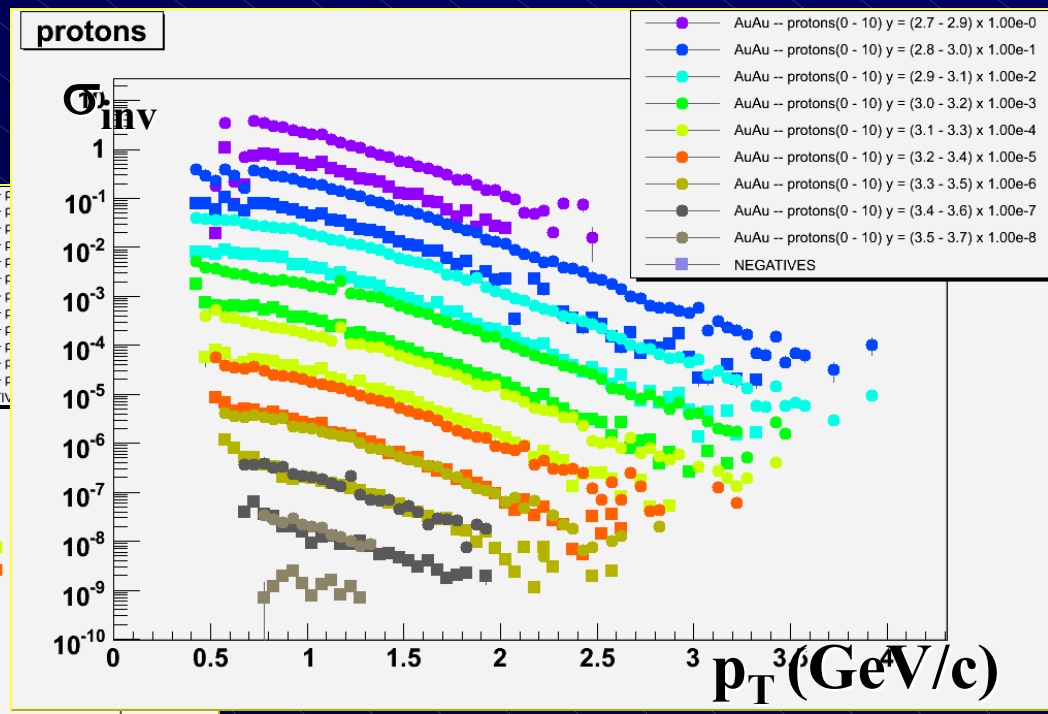
Sample of spectra at high rapidity in BRAHMS

protons

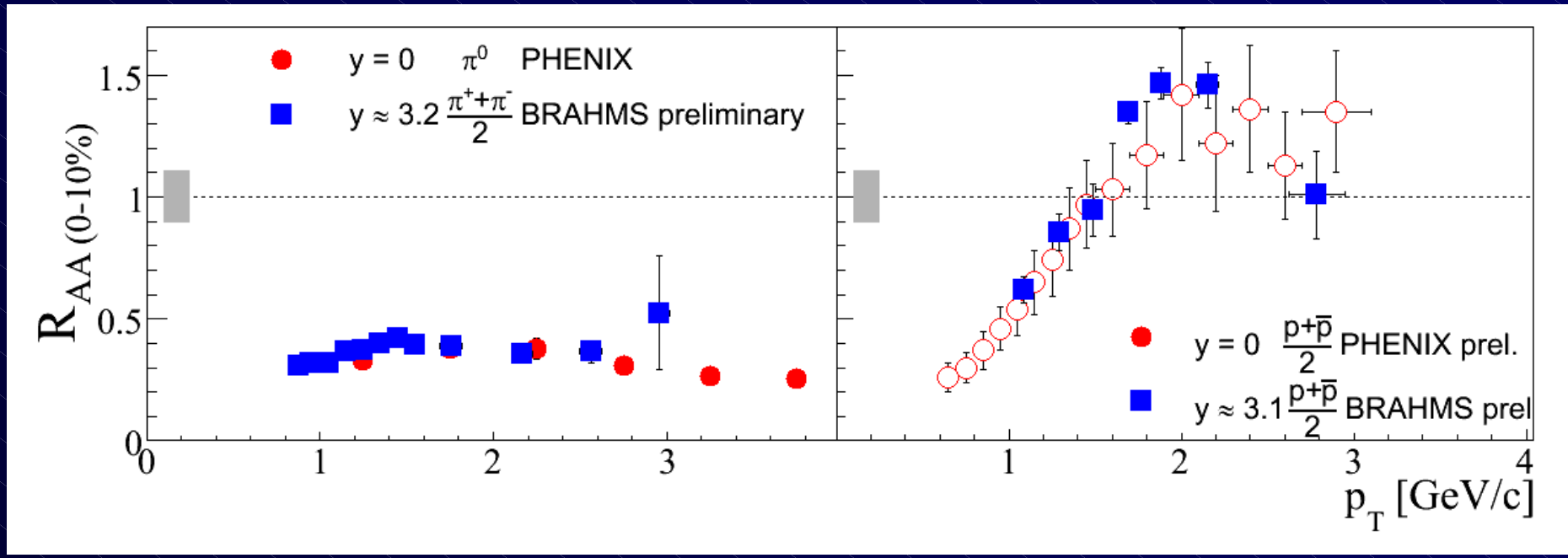
pions

y 2.8 -> 4.1



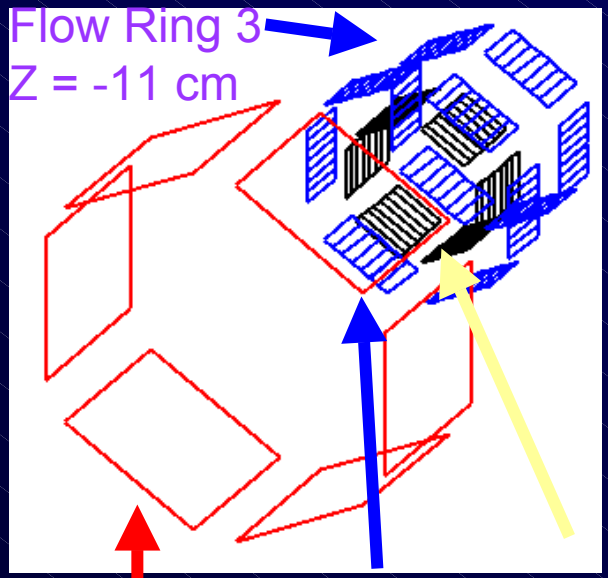


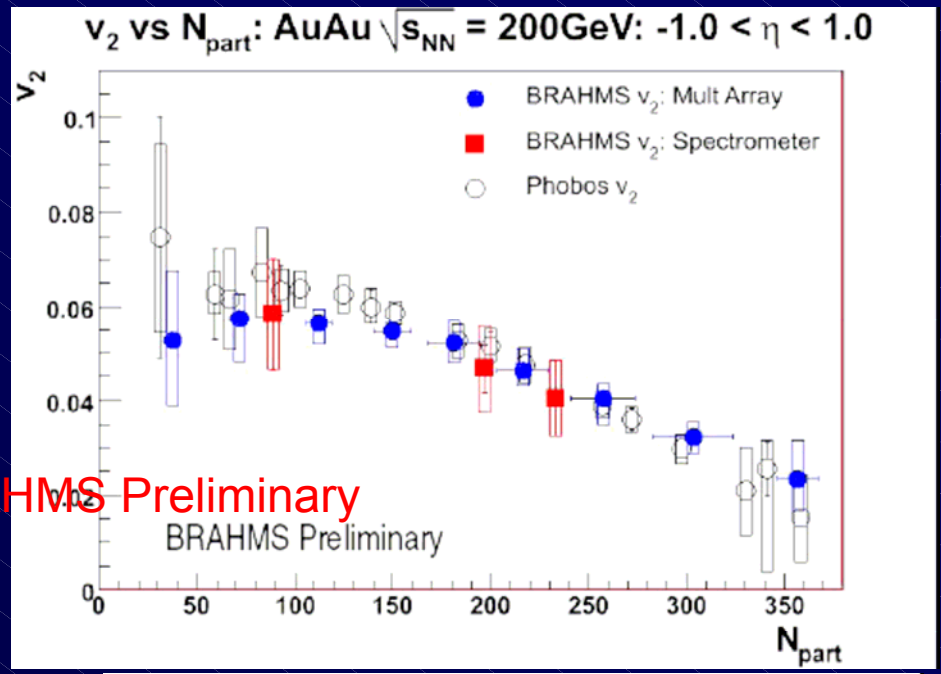
Rapidity dependence of high-p_T Suppression for identified particles.



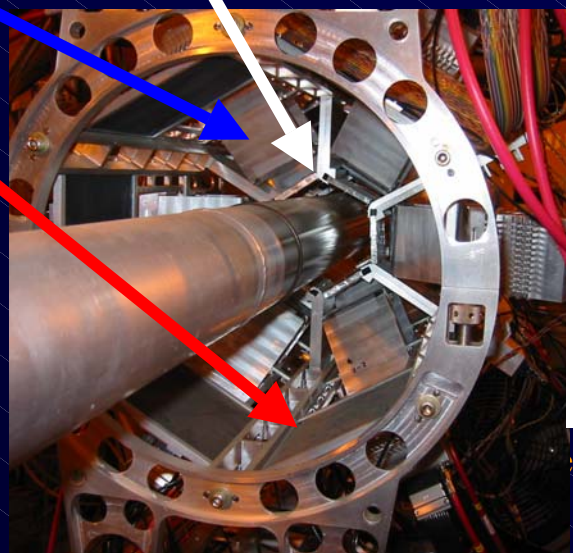
R_{AA} depends little on rapidity even for identified particle.
Pions suppressed; protons not
R_{AA} depends on energy-loss, density and underlying reference spectrum

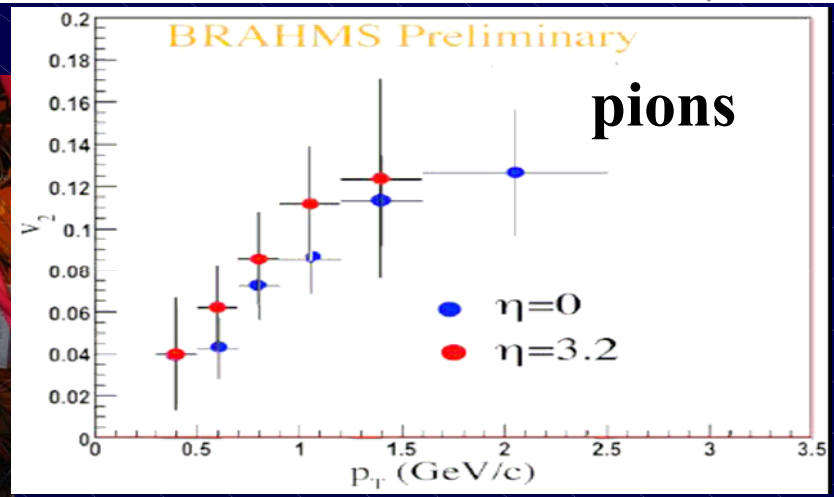
Elliptic flow in BRAHMS



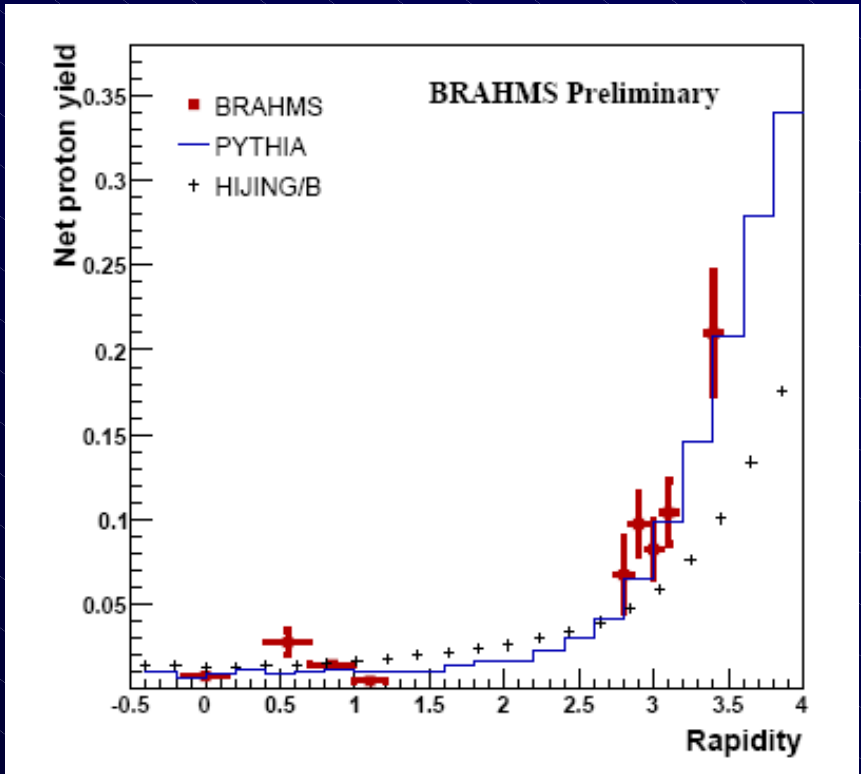


BRAHMS Preliminary



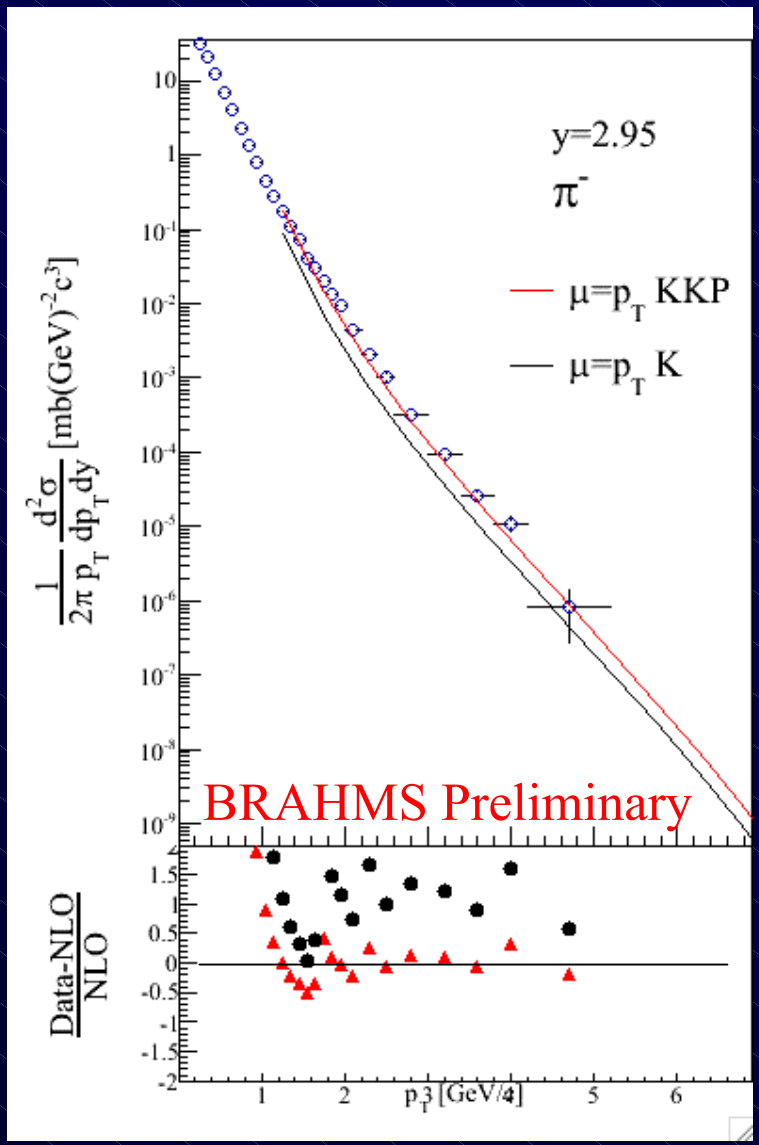


Baryon Transport/Stopping in pp



The high rapidity measurements allow to get a handle on baryon transport and stopping via net proton distributions.

NLO pQCD for pions compared to data



Calculations done by W. Vogelsang. Only one scale $\mu=p_T$ and the same fragmentation functions as used for the PHENIX comparison.

KKP has only π^0 frag. Needed some modification to produce charged pions

KKP FF does a better job compared to Kretzer, Pi and Kaon production still dominated by gg and gq at these rapidities apart from the highest p_{Tcc}

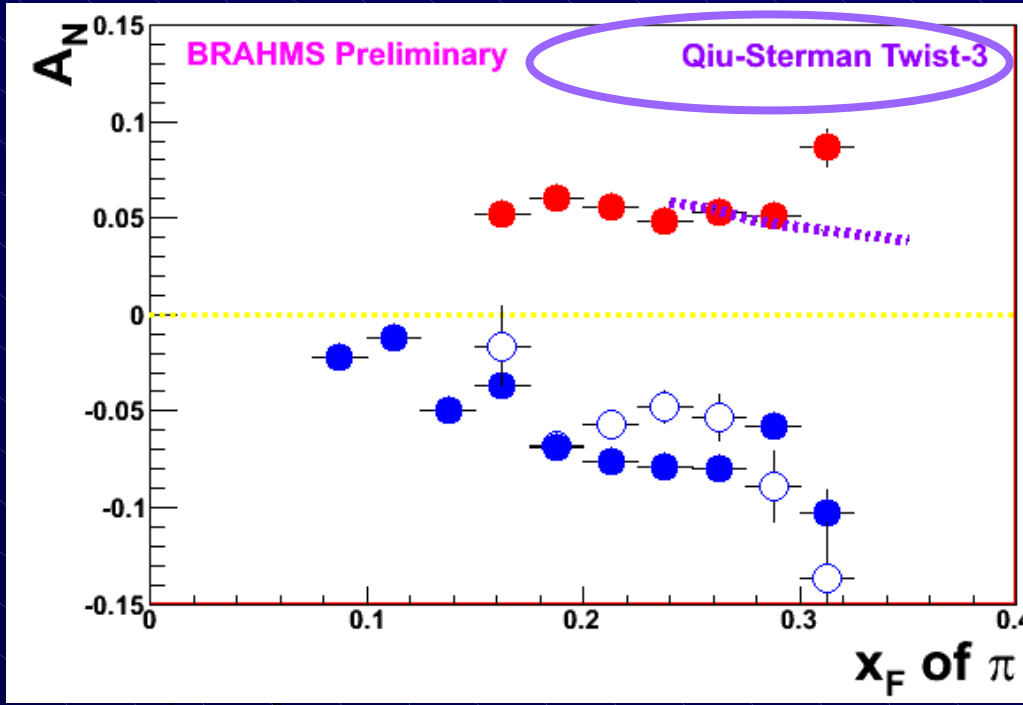
Transverse Single Spin Asymmetries measurements in BRAHMS

BRAHMS measures identified hadrons (π,K,p,pbar) in kinematic ranges of $0<Y<3.5$ and $0.2<p_T<4$

Data:

- Run-4: First SSA measurements in BRAHMS
- Run-5: pp at $\sqrt{s}$ = 200 GeV 2.5 pb^{-1} recorded
- Run-6: pp at $\sqrt{s}$ = 62 GeV planned (Energy dependence)

A_N(π,K,p,pbar) in $0.1 < x < 0.35$ from Run-5 has been analyzed.



Twist-3 (initial state) calculations by Qiu and Sterman:
Extrapolated to lower p_T region
Phys. Rev D59 014004 (98)

Publications

2000-2006 **15** Refereed Journals
2000-2005 **56** Conference proceedings
2000-2005 **105+** Talks at conferences , meetings and workshops

- *Recent Publications*
- *"Rapidity dependence of high pT suppression at sqrt(sNN)=62.4 GeV"*
  Submitted to Phys.Rev.Lett. nucl-ex/0602018,
- "Centrality Dependent Particle Production at y=0 and y~1 in Au+Au Collisions at sqrt(s_{NN}) = 200 GeV" **Phys. Rev. C72, 014908 (2005)**
- "Charged Meson Rapidity Distributions in Central Au+Au Collisions at sqrt(s_{NN}) = 200 GeV" **Phys. Rev. Lett. 94, 162301 (2005)** , nucl-ex/0403050
- "Forward and Midrapidity Like-particle Ratios from p+p Collisions at sqrt(s_{NN})=200 GeV") **Phys. Lett. B607, 42-50 (2005)**
- "Centrality Dependence of Charged-particle Pseudorapidity Distributions from d+Au Collisions at sqrt(s_{NN})=200 GeV" **Phys. Rev. Lett. 94, 032301 (2005)** , nucl-ex/0401025

Citations

- 5 top citations from BRAHMS
  - **(173) TRANSVERSE MOMENTUM SPECTRA IN AU+AU AND D+AU COLLISIONS AT S**(1/2) = 200-GEV AND THE PSEUDORAPIDITY DEPENDENCE OF HIGH P(T) SUPPRESSION.**
    Published in **Phys.Rev.Lett.91:072305,2003**
  - (144) **Quark gluon plasma and color glass condensate at RHIC? The Perspective from the BRAHMS experiment.**
  - Published in **Nucl.Phys.A757:1-27,2005**
  - **(112) ON THE EVOLUTION OF THE NUCLEAR MODIFICATION FACTORS WITH RAPIDITY AND CENTRALITY IN D + AU COLLISIONS AT S(NN)**(1/2) = 200-GEV.**
    Published in **Phys.Rev.Lett.93:242303,2004**
  - **(85) PSEUDORAPIDITY DISTRIBUTIONS OF CHARGED PARTICLES FROM AU+AU COLLISIONS AT THE MAXIMUM RHIC ENERGY.**
    Published in **Phys.Rev.Lett.88:202301,2002**
  - **(78) Charged particle densities from Au+Au collisions at s(NN)**(1/2) = 130-GeV .**
    Published in **Phys.Lett.B523:227-233,2001**
- Total citations (- self citations) 874

Collaboration

Educational Output

11 Institutions in 5 Countries.

36 Scientists, 3 Post Docs, 6 Ph.D students, 5 MS students

Year	Ph.D thesis
2006	1
2005	3
2004	2
2003	2
2002	1
..2001	2

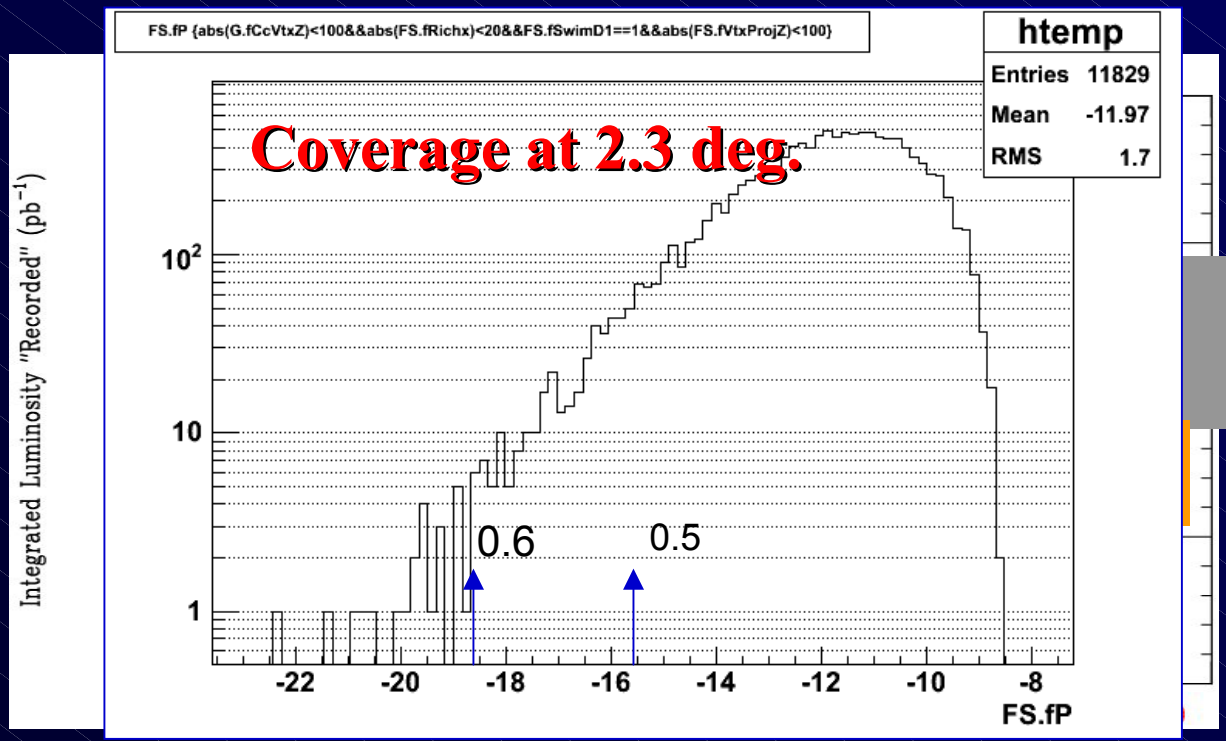
In addition ~15 M.S. thesis

Run-6 pp Data Taking

Goals for 62 GeV were

- Reference spectra for AA at y~0 and y~3
- Single Spin Asymmetries out to x_F=0.55

Experiment was unchanged from and setup tuned on a small number of stores at 200 GeV (Feb+June)



Calibrations and reconstruction are in progress.

Analysis Status

- BRAHMS Measurements are completed with the extended high luminosity runs of Au-Au , Cu-Cu and pp at 200 and 62.4 GeV
- The focus has been on unique forward coverage
  - Transverse spectra of π, K, p
  - Elliptic Flow
  - Small-x physics
  - Transverse flow
  - Suppression of high p_T particles
  - Transverse spin measurements at x^F=0.2 to 0.4 (200 and 62 GeV)
  - Data production have been completed, detailed
  - Analysis and publication of data will take ~1.5 additional years (based on experience with similar size experiments)
- This matches the time-scale for several students and post docs, involvement of European groups that go to ALICE, US groups that will/is be involved in STAR, CMS and ATLAS.

Analysis priorities

- AuAu 62 and 200 GeV
  - Differential flow analysis for identified hadrons.
  - Rapidity and centrality dependence of pt-suppression
  - Rapidity and centrality dependence of soft physics
- CuCu 62 and 200 GeV
  - Comparison of particle production and pt dependence at 62 GeV and 200 GeV
  - Comparison of jet-quenching via Rcp and RAA to AuAu
  - Volume and geometry dependence of AA.
- Pp at 200 GeV
  - Spin Asymmetries A_N (bulk of data)
  - High pt flavor dependence of hadron production
- Pp at 62 GeV
  - Reference spectra for AA and SSA at large x^F
- dA at 200
  - Revisiting identified spectra at large η.

Conclusions

- BRAHMS has performed an extensive survey of identified hadron production with its unique y-p_t coverage in Heavy Ion reactions at RHIC
- The flexibility of the experiment and RHIC facility allowed for unique measurements in d-Au and spurred extensive interest in low-x physics at RHIC and LHC
- BRAHMS has contributed with significant and unique measurements for the RHIC spin program
- The Collaboration has sufficient resources to complete the remaining bulk of analysis and publications in a time frame of ~1-1.5 years, matching the timeframe of students staff moving to other projects.